Differential Renal Function Study

An Aid in Preoperative Evaluation of Hypertensive Patients

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■ *Non-occlusive ureteral catheters were placed bilaterally in the renal pelves of 30 patients known to have hypertension. Samples of urine were collected under conditions of normal hydration, of urea-PAH-saline diuresis and, in some cases, mannitol diuresis. The samples were analyzed for indications of impaired flow of blood to the kidneys. Aortograms were obtained in all cases.*

This placement of non-occlusive catheters up into the renal pelves was felt to have caused only minimal disturbance of renal function, and was not accompanied by ureteral edema with the concomitant complications caused by occlusive catheters. Under conditions of normal hydration, leakage was insignificant.

Of the 20 patients in whom urea-PAH-saline infusion revealed an ischemic pattern, 19 had an ischemic pattern under conditions of normal hydration. Since in the one exception an aortographic examination did not show a surgically reparable renal lesion, it may be inferred that the use of urea-PAH-saline diuresis is not essential in the preoperative evaluation of hypertensive renal disease.

Correlation of the results of differential renal function studies and aortographic findings was possible in 19 of the 30 patients. Lack of correlation in the remaining 11 patients emphasized the importance of obtaining both types of study.

Aortographic examination combined with differential renal function studies, using small ureteral catheters under conditions of normal hydration, should give the urologist a practical and yet accurate method of determining differential renal blood flow. If desired, further verification could be obtained by administering contrast medium and performing serial measurements of urine density.

WITH A BETTER UNDERSTANDING of renal physiology and improved techniques in vascular operations, surgical treatment of hypertension secondary to renal vascular disease has come to the fore. The results of treatment, however, have been variable, with success depending to a large extent on careful selection of patients through preoperative evaluation.

A surgically reparable lesion of the renal vasculature is best demonstrated visually by aortography. However, a lesion that is demonstrated aortographically is not necessarily a lesion that causes hypertension; the caliber of the renal artery must be decreased by 50 per cent before a de-

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crease in renal blood flow can be detected.[5] Thus, preoperative evaluation must also include tests that give some indication of the supply of blood to the kidneys.

The most practical means of evaluating renal blood flow is by measuring the physiological effects of its impairment. This is accomplished through tests of differential renal function. The procedure outlined by Stamey (1962)[5] is probably the most accurate of the differential renal function studies. It is based on sound physiological principles. The ischemic kidney is a water-reabsorbing kidney and the urea administered for the Stamey test potentiates this reabsorption. Determinations of urine volume reflect most sensitively the degree of reabsorption. As now performed, the Stamey test requires the use of unilateral or bilateral occlusive catheters placed part way up the ureters. Various complications of this test have been reported.[6]

The purposes of the present study were: (1) to determine if a satisfactory study could be carried out with catheters of less than occlusive size inserted to a level just above the ureteropelvic junction; (2) to determine if the administration of urea is necessary for the detection of renal impairment due to decreased renal blood flow; and (3) to correlate the results from the differential renal function studies with the aortographic findings in the same patients to see if both diagnostic methods are essential in the preoperative evaluation of these patients.

Materials and Methods

Samples of urine were obtained from 30 hypertensive patients under conditions of normal hydration, of ureapara-aminohippuric acid-saline diuresis, and, in some cases, mannitol diuresis. Aortograms, excretory urograms and occasionally radioisotope renograms and renal scintigrams had been taken in these patients.

A series of nine collections (18 unilateral specimens obtained from each patient through whistle-tipped catheters—No. 6F in males and No. 7F in females—placed just above the ureteropelvic junctions) were analyzed for volume, osmolarity, concentrations of electrolytes, creatinine, urea nitrogen, phosphate and para-aminohippuric acid (PAH). Also determined were differential phenolsulfonphthalein (PSP) excretion and concentration[6] as well as specific gravity of urine from each kidney following the intravenous administration of contrast medium.[1,2] All differential renal function studies were performed by the same person.

Differential Renal Function Tests

When the flow of blood to one kidney is impaired, excessive reabsorption of water by that kidney and increased concentration of excretory products in the urine from that kidney occur. These excretory products can be endogenous (such as potassium or creatinine) or exogenous (such as PAH, PSP dye, or any contrast medium similar to those used for excretory urography). In a "classic" case of renal artery stenosis (Figure 1) the findings on excretory urography are: (1) a smaller kidney, (2) delayed appearance of the dye, followed by (3) hyperconcentration of the dye, all on the involved side. It is impossible visually to measure accurately the degree of this concentration of contrast substance. However, an objective measurement of the concentration of

Figure 1.—*Left,* aortogram showing a stenotic area of the right renal artery. *Right,* excretory urogram demonstrates *(in the upper frame)* the smaller right kidney with delayed excretion of contrast substance. The 30-minute exposure *(lower frame)* is suggestive of hyperconcentration on the right side.

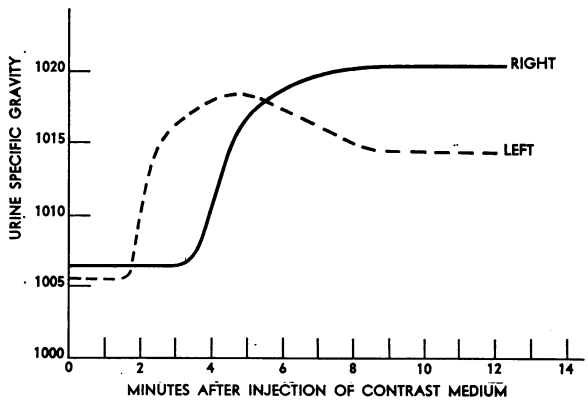

Chart 1.—Curves of urine gravity in a case of right renal artery stenosis. Note the delayed ability of concentration followed by hyperconcentration from the right kidney.

contrast substance can be obtained by measuring with a refractometer the specific gravity of samples of urine obtained simultaneously from both kidneys.[1,4] The measurements are charted for each kidney as shown in Chart 1. In the present study, the results of these measurements correlated well with the findings from other tests for determining impaired renal blood flow.

Of the various excretory products determined, creatinine concentration was the most reliable as an indicator of renal ischemia. The differences in concentration of urea nitrogen were less pronounced, and were probably secondary to the increased reabsorption of urea in the presence of decreased tubular flow of urine in the ischemic kidney.[3] The ratio of urea to creatinine might, therefore, be a useful adjunct in the preoperative evaluation of a patient with an ischemic kidney.

Determinations of phosphate followed the same pattern of increased concentration from the ischemic kidney, but to a lesser degree than the other substances. Sodium and chloride concentrations were unreliable tests under conditions of urea-PAH-saline diuresis.

Leakage around the catheters was almost nonexistent under conditions of normal hydration, and averaged approximately 6 per cent under urea or mannitol diuresis. Where small volumes allowed for complete flow without leakage, measurement of total excretion and concentration of PSP accurately demonstrated unilateral renal ischemia. No evidence of ureteral edema was encountered.

Urea-PAH-saline stimulation revealed an ischemic pattern in 20 patients. In 19 of them there was an ischemic pattern under conditions of normal hydration as well. In the one patient in whom urea diuresis revealed an ischemic pattern and the findings under normal hydration were essentially normal, there was no lesion apparent on aortographic examination. This suggests that urea diuresis is not necessary for detecting a surgically reparable lesion. Mannitol diuresis, in contrast to urea diuresis, decreased the differences between the two kidneys by diminishing the osmotic gradient in the medullary tissue.

Correlation of Aortograms and Renal Function Studies

In 14 of the 30 patients tested, an ischemic kidney was demonstrated both by aortographic examination and differential renal function studies (Table 1). In five patients, no ischemic pattern was detected nor was there visual evidence of a vascular lesion. However, in the remaining 11 patients, there was no correlation, and this lack of correlation should point up the importance of carrying out both types of diagnostic testing in order to plan a rational surgical approach.

From the evidence that we have at present, an aortographically demonstrable lesion that does not cause an ischemic pattern in function studies must

TABLE 1.—*A Comparison of the Results of the Test of Differential Renal Function with Findings on Aortographic Examination in a Series of 30 Patients with Hypertension*

	Number of Patients
I. Correlation of aortographic observations with function studies	
A. Lesion on aortogram and ischemic pattern in function study	14
B. No lesion on aortogram and no ischemic pattern in function study*	5
Total	19
II. Lack of correlation of aortographic observations with function studies	
A. Lesion on aortogram and no ischemic pattern in function study	3
B. No lesion on aortogram and ischemic pattern in function study	3
C. Lesion on aortogram on side opposite from that showing ischemic pattern in function study	2
D. No lesion on aortogram and questionable false positive ischemic pattern (pyelonephritis) in function study	3
Total	11

*One of these patients showed an ischemic pattern under urea diuresis.

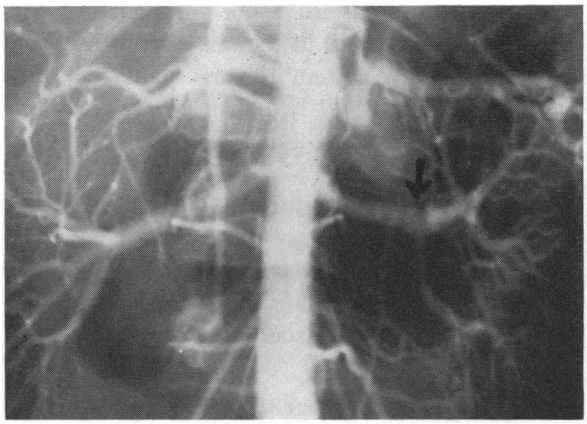

Figure 2.—Aortogram showing fibromuscular hyperplasia in the left renal artery. An ischemic pattern was found on function study from the right kidney.

be assumed to be insufficiently occlusive to cause a perceptible decrease in renal blood flow, and, therefore, is probably not responsible for the patient's hypertension. Where no lesion is seen grossly on an aortogram, and yet an ischemic pattern is noted in function studies, multiple segmental or branch lesions may be limiting the overall decreased vascular supply to the kidney. It is unlikely that patients of this order should be treated surgically.

The situation that best points out the importance of performing both types of study is one where an ischemic pattern is noted in the kidney opposite a kidney in which a lesion has been noted aortographically. Figure 2 shows the aortogram of a ten-year-old boy who had had severe hypertension from the age of three months. The obvious lesion of the left renal artery was felt to be one of fibromuscular hyperplasia; the vasculature to the right kidney was grossly normal. Yet from the right kidney, an ischemic pattern was obtained.

In contrast to the excessive water-reabsorbing pattern characteristic of renal ischemia, a pyelonephritic kidney may excrete a greater fraction of its filtered water than the contralateral kidney. This may lead to possible false interpretation of an ischemic pattern for the normal kidney. Fortunately, a history of recurrent infections or a urographic examination will usually clarify the situation.

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Correction

Table 2 which appeared in the article, "Rubella and the Rubella Syndrome—New Epidemiologic and Virologic Observations," by Dorothy M. Horstmann, M.D., in the June issue of CALIFORNIA MEDICINE contained erroneous entries. The corrected version follows:

TABLE 2.—*Virus Isolation from Fetal Tissue Obtained at Induced Abortion*

Weeks After Maternal Rubella	*Virus Isolations*	
	Number Positive	*Number Tested*
< 2	2	3
2 - 3	4	5
4 - 5	2	4
6 - 7	1	3
8 - 9	1	1
> 9	0	2
Total isolations	10 (56%)	18